US008887676B2

(12) **United States Patent**
Methley et al.

(10) **Patent No.: US 8,887,676 B2**
(45) **Date of Patent: Nov. 18, 2014**

(54) **CAMSHAFT AND PHASER ASSEMBLY**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 280 days.

(21) Appl. No.: **13/145,103**

(22) PCT Filed: **Jan. 27, 2010**

(86) PCT No.: **PCT/IB2010/050357**

§ 371 (c)(1), (2), (4) Date: **Dec. 6, 2011**

(87) PCT Pub. No.: **WO2010/086799**

PCT Pub. Date: **Aug. 5, 2010**

(65) **Prior Publication Data**

US 2012/0067310 A1 Mar. 22, 2012

(30) **Foreign Application Priority Data**

Jan. 30, 2009 (GB) 0901478.8

(51) **Int. Cl.**

F01L 1/34 (2006.01)
F01L 1/047 (2006.01)
F01L 1/344 (2006.01)

(52) **U.S. Cl.**

CPC ***F01L 1/047*** (2013.01); *F01L 2001/34493* (2013.01); ***F01L 1/3442*** (2013.01); *F01L 2001/0473* (2013.01)

USPC **123/90.17**

(58) **Field of Classification Search**

USPC 123/90.15, 90.17, 90.6; 464/160, 161; 29/888.1

See application file for complete search history.

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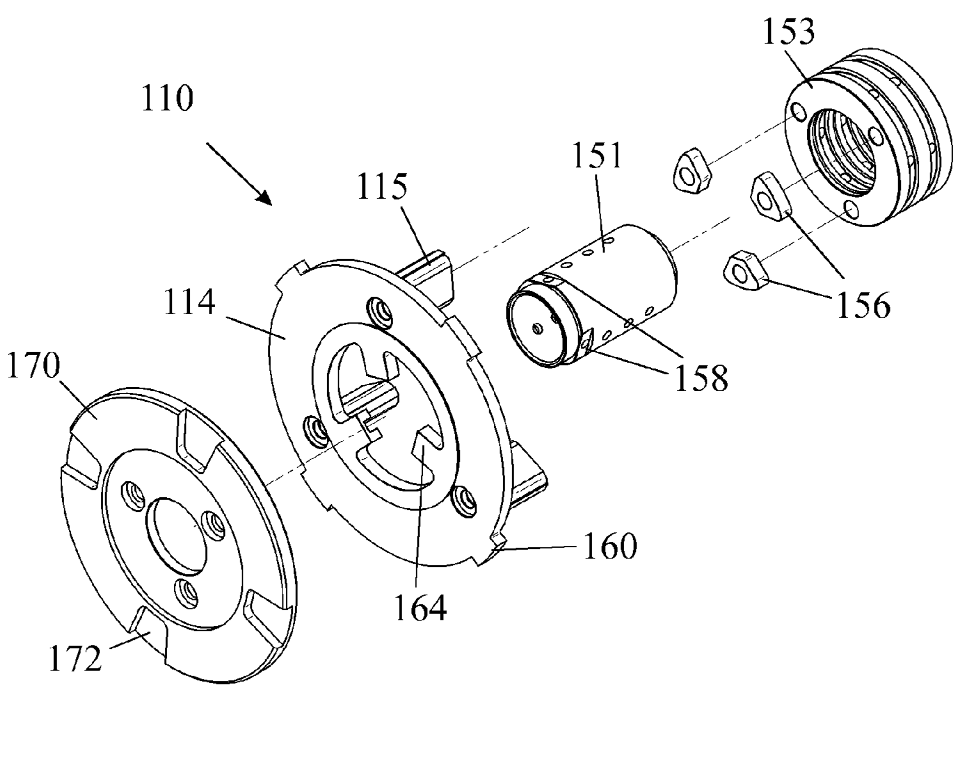
(57) **ABSTRACT**

An assembly is disclosed which comprises an SCP camshaft **130** and a phaser mounted at one end of the SCP camshaft. The phaser has a stator **112** driven by an engine crankshaft and two output members **114**, **116** each fast in rotation with a respective one of the inner shaft **140** and the outer tube **126** of the SCP camshaft **130**. Two timing features **160**, **172** are provided for enabling respective sensors to determine the angular positions of the inner shaft and the outer tube of the SCP camshaft. In the invention, both timing features **160**, **172** are located on the side of the stator **112** remote from the camshaft **130**.

7 Claims, 3 Drawing Sheets



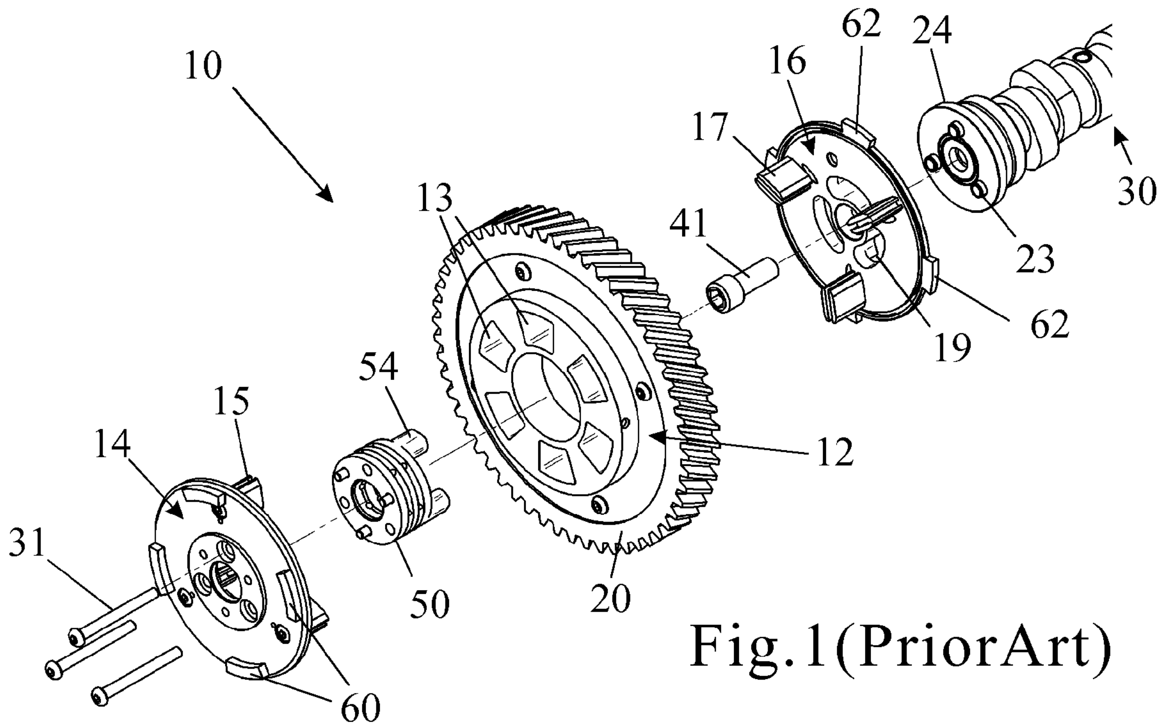


Fig.1(PriorArt)

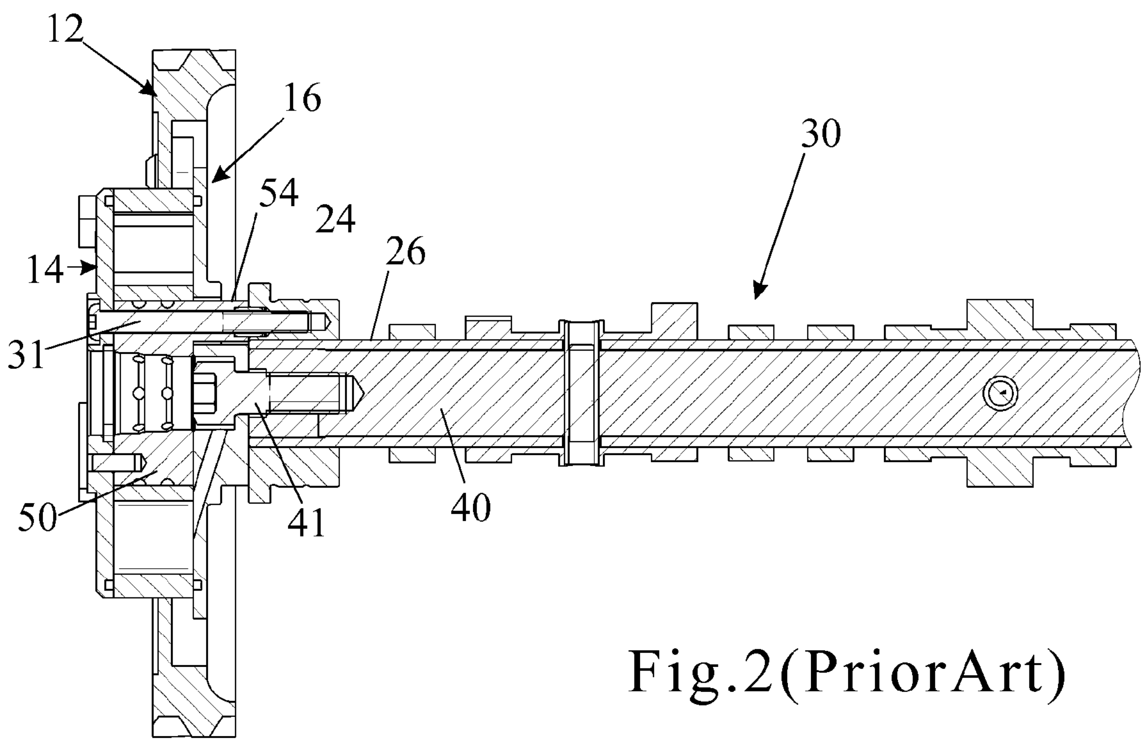


Fig.2(PriorArt)

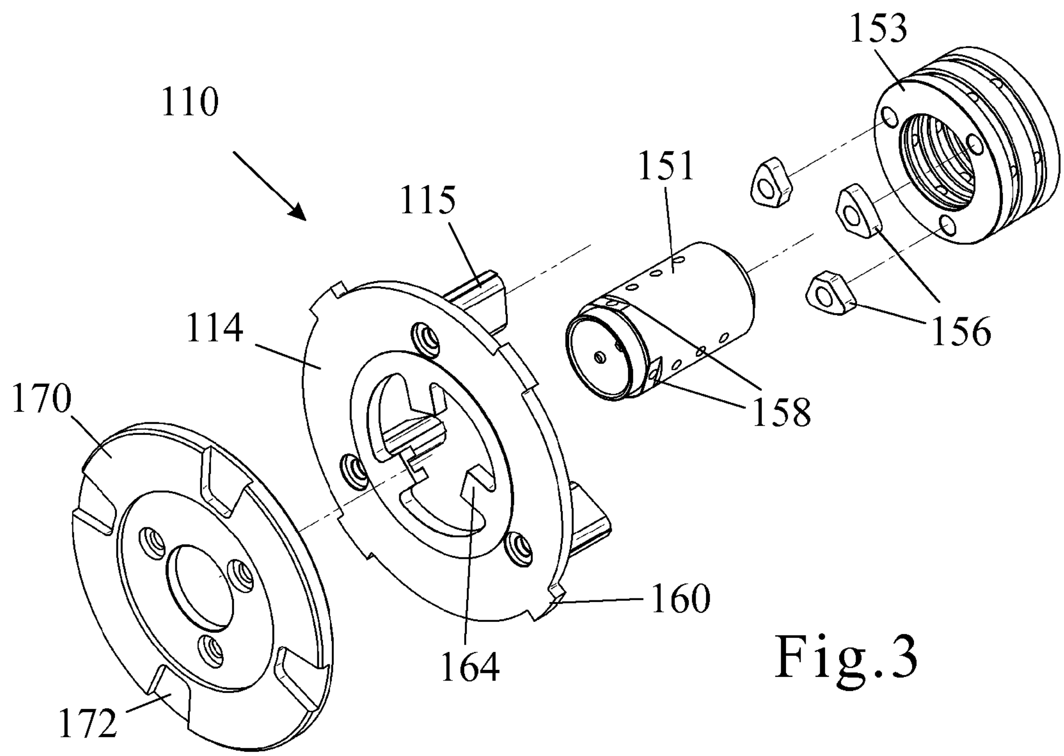

153
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Fig.3

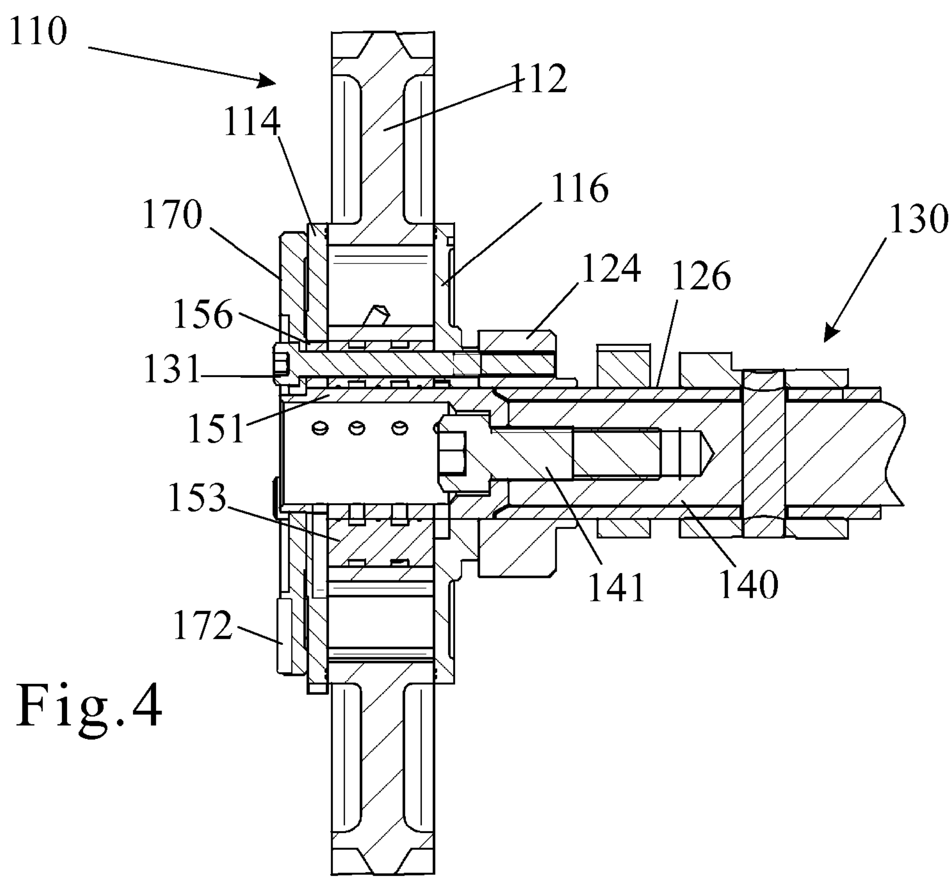
110
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Fig.4

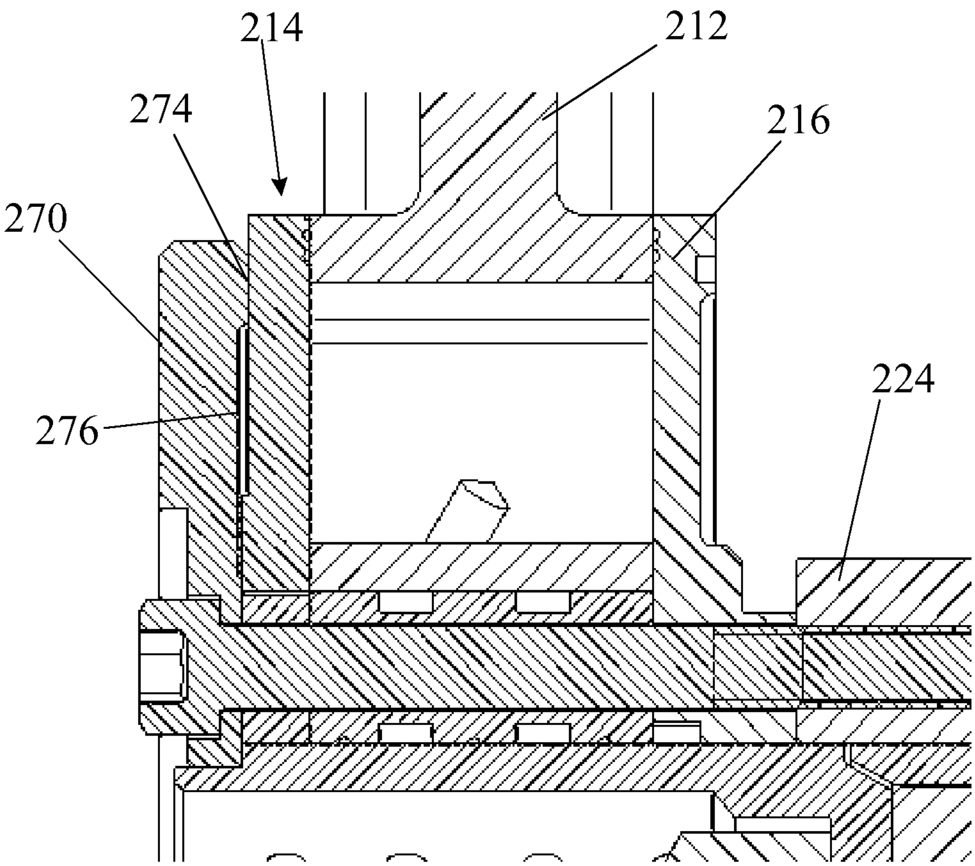

Fig.5

CAMSHAFT AND PHASER ASSEMBLY

FIELD OF THE INVENTION

The present invention relates to a camshaft having an inner shaft and an outer tube that are rotatable relative to one another, a first set of cams secured for rotation with the outer tube, and a second set of cams rotatably mounted on the outer tube and connected for rotation with the inner shaft by way of pins that pass with clearance through circumferentially elongated slots in the outer tube, and a phaser mounted at one end of the camshaft.

BACKGROUND OF THE INVENTION

Assembled camshafts are known, for example from WO2008/075094, GB 2424258 and EP 1362986, which comprise an inner shaft and an outer tube that are rotatable relative to one another. A first set of cams is secured for rotation with the outer tube while a second set of cams is rotatably mounted on the outer tube and is connected for rotation with the inner shaft by way of pins that pass with clearance through circumferentially elongated slots in the outer tube. Such a camshaft, which allows the relative phase of cams rotatable about a common axis to be changed, is referred to herein as an SCP camshaft.

There are also known hydraulically operated vane-type cam phasers that are intended to drive an SCP camshaft, an example of such is a phaser as disclosed in U.S. Pat. No. 6,725,817. Such phasers will herein be referred to as twin phasers, because they have two output members, one for driving the inner shaft of the SCP camshaft and the other for driving its outer tube. The phase of both of the output members are adjustable hydraulically relative to the engine crankshaft, such as by controlling the flow of oil under pressure to arcuate working chambers arranged on opposite sides of radial vanes connected to a respective one of the output members. This could equally be achieved with two single phasers arranged in series or parallel, attached to the front of the SCP camshaft.

A known SCP camshaft and twin phaser assembly based on the disclosure of WO2008/075094 and believed to represent the closest prior art will now be described with reference to the accompanying FIGS. **1** and **2**, in which FIG. **1** shows an exploded view of the twin phaser and the front end of the camshaft while FIG. **2** shows an axial view through the twin phaser when assembled on the camshaft.

In the twin phaser **10** of FIGS. **1** and **2**, the phase of each of two output members, formed as end plates **14**, **16**, is adjustable relative to the engine crankshaft. The phaser has a stator **12** formed as a gear **20** to be driven by the engine crankshaft. If the phaser is chain driven, the gear **20** would be replaced by a sprocket. The stator **12** is annular and has six arcuate recesses **13**. Three of the recesses receive vanes **15** projecting from the front end plate **14** and the other three receive vanes **17** projecting from the rear end plate **16**.

The camshaft **30** terminates within a front bearing **24** which is formed with three screw threaded holes receiving ring dowels **23** and is fast in rotation with the outer tube **26** of the camshaft **30**.

The twin phaser **10** is supported on a bearing support **50** which comprises a ring with three axially projecting hollow legs **54**. The ring **50** is engaged in use by an oil feed spigot that projects from a cover overlying the front end of the engine block. The front cover may, for example, be an adaptation of that described in GB-A-2,329,675. The stator **12** of the twin phaser is in turn supported by the radially outer surface of the

support bearing **50** and can rotate through only a few degrees relative to it. Various passageways and oil grooves in the support bearing **50** allow oil from the engine front cover to be supplied under pressure to the working chambers of the twin phaser **10**.

The legs **54** of the support bearing **50** pass through three arcuate clearance slots **19** formed in the rear end plate **16** to contact the axial end face of the bearing **24** that is mounted on the outer tube **26** of the SCP camshaft **30**. The bearing support **50** is axially clamped between the front plate **14** of the twin phaser **10** and the bearing **24** by means of three bolts **31** which pass through the hollow legs **54** and clamp the front end plate **14**, the support bearing **50** and the bearing **24** to one another. This ensures that the front end plate **14** is fixed both axially and rotationally in relation to the outer tube **26** of the SCP camshaft **30**.

Additionally, the hollow legs **54** of the support bearing **50** are aligned in relation to the bearing **24** by means of the ring dowels **23** that project from the axial end surface of the bearing **24** into the hollow legs **54** of the support bearing **50**.

The rear end plate of the twin phaser **10** is directly secured onto the inner shaft **40** of the SCP camshaft **30** by means of a bolt **41** that is screw threaded into a bore in the axial end face of the inner shaft **40**.

In the above described assembly, the two output members of the twin phaser are arranged one at the front, namely the end plate **14**, and the other at the rear, namely the end plate **16**. In an internal combustion engine, it is necessary to sense the angular position of these output members so that the electronic engine control unit (ECU) can correctly control camshaft timing.

Though not specifically described in WO2008/075094, the front and rear output members produced by the present Applicants did in practice have timing features on them, for triggering adjacently mounted sensors. In FIG. **1**, the timing feature on the front plate **14** comprises four axially projecting teeth **60** and that on the rear plate comprises four radially projecting teeth **62**. The sensors need to be positioned next to these timing features in such a way that electrical sensor signals are generated, which can be used by the ECU to control the phaser **10**.

SUMMARY OF THE INVENTION

According to the present invention, there is provided an assembly as described above in which both the timing features rotatable in unison with the respective output members of the phaser are located on the side of the stator remote from the camshaft.

As earlier mentioned, timing features **60** and **62** were used in a twin phaser of the type shown in WO2008/075094 on both the front and the rear output member. While a sensor can readily be mounted to interact with the timing feature **60** on the front output member **14**, the rear output member **16** is relatively inaccessible. It is consequently difficult to position a sensor to interact with the timing feature **62** on the rear output member **16** without significant modification to the cylinder block or cylinder head.

The present invention mitigates this problem by locating the timing features that indicate the angular positions of both output members on the front side of the phaser, that is to say the side remote from the camshaft, where they are readily accessible.

In a preferred embodiment of the invention, the stator is supported on a bearing which is connected for rotation with the outer tube and one of the timing features. A second co-axial inner sleeve is connected for rotation with the inner shaft and the other of the timing features.

Conveniently, the phaser is constructed as a vane-type twin phaser, the output members being formed by the two end plates of the phaser. In such a case, the rear end plate of the phaser is advantageously connected directly to the outer tube of the SCP camshaft.

The timing feature indicating the angular position of the rear end plate of the phaser is preferably formed as a separate trigger ring located at the front end of the phaser, the trigger ring, the support bearing and the rear end plate being clamped to the front of the camshaft.

The rear face of the trigger ring may in such a construction serve to control the internal clearance between the moving plates within the phaser.

It is furthermore possible for a space between the trigger ring and the front end plate of the phaser to be sealed so as to define a hydraulic cavity which, when pressurised, applies a force to reduce clearances within the phaser.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is an exploded view of a prior art assembly of the type known from PCT/GB2007/050736,

FIG. **2** is a cut-away direct view of a prior art assembly of the type known from PCT/GB2007/050736, show in FIG. **1**,

FIG. **3** is a partial exploded view of an assembly of the invention showing only the trigger ring, the front end plate, the inner co-axial sleeve of the phaser and the support bearing for the phaser,

FIG. **4** is an axial section showing the same embodiment of the invention as shown in part in FIG. **3**, and

FIG. **5** is a close-up section similar of FIG. **4** for the description of an alternative embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. **3** and **4**, components identical to those earlier described with reference to FIGS. **1** and **2**, or serving a similar function, have been allocated the same reference numerals as previously but in the "100" series. In the same way, the embodiment of FIG. **5** has been allocated reference numeral in the "200" series.

FIG. **3** does not show the stator **112**, nor the back plate **116** of the phaser **110** but these are shown in FIG. **4**. In place of the single piece support bearing **50** of FIGS. **1** and **2**, the embodiment of the invention shown in FIGS. **3** and **4** has a support bearing **153** does not have any protruding legs and an inner sleeve **151** is arranged within the support bearing **153** is. Both of these components are formed with passageways for supplying oil to the working chambers of the vane type phaser in the same way as described in PCT/GB2007/050736. In particular, a front cover fitted to the engine has a stationary projecting spigot that fits within the inner sleeve **151** and is sealed relative to it by suitable rotary seals.

As compared with FIGS. **1** and **2**, the embodiment of the invention shown in FIGS. **3** and **4** reverses the manner in which the end plates **114** and **116** are coupled to the SCP camshaft **130**. In particular, the front end plate **114** is coupled for rotation with the inner shaft **140** of the SCP camshaft, while the rear end plate **116** and a trigger ring **170** are clamped for rotation with the outer tube **126** of the camshaft **130**. In both cases, as will now be described, the connection is made via either the support bearing **153** or the inner sleeve **151**.

Three screw threaded bolts **131** are engaged in threaded holes in the front camshaft bearing **124**, which is mounted on the outer tube **126** of the camshaft **130**. The bolts **131** pass first through the trigger ring **170**, then through spacers **156**, then holes in the support bearing **153** and finally through holes in the rear end plate **116** before being screwed into the camshaft bearing **124**. When the bolts **131** are tightened, they clamp the trigger ring **170**, the support bearing **153**, the rear end plate **116** and the camshaft bearing **124** for rotation with one another but, because of the spacers **156**, the front end plate **114** can rotate relative to all these components and also relative to the stator **112**.

The inner sleeve **151** is secured by a bolt **141** to the inner shaft **140** of the camshaft **130** and the front end plate has three radially inwardly projecting fingers **164** which engage with flats **158** on the outer surface of the inner sleeve **151**. As a result, the front end plate **114** rotates in unison with the inner sleeve **151** and the inner shaft **140** of the camshaft **130**.

The trigger ring **170** has a timing feature in the form of recesses **172** which indicates the angular position of the outer tube **126** of the camshaft **130**. Likewise, the front end plate **114** has a timing feature in the form of radial teeth **160** which indicates the angular position of the inner shaft **140** of the camshaft **130**. Unlike the prior art, both timing features are accessible from the front side of the phaser, that is to say the side remote from the camshaft **130**.

The important differences between the preferred embodiment of the invention and the prior art are the following:

- The inclusion of an inner sleeve **151** which connects the front end plate **114** to the inner shaft **140** of the camshaft **130**.
- The provisions of a front trigger ring **170** that is clamped to the support bearing **153** via spacers **156**, the spacers **156** being needed to ensure the front plate **114** is not clamped to the support bearing **153**. It should be noted in this respect that the spacers could alternatively form an integral part of the trigger ring **170** or the support bearing **153**.
- The rear end plate **116** is clamped between the support bearing **153** and the front cam bearing **124**.

As well as overcoming the problems associated with sensing the angular position of both the front and rear end plates of the phaser, the embodiment of FIGS. **3** and **4** offers the following advantages:

- Simplified design of the support bearing **153** (just a simple cylinder).
- Simplified design of the rear phaser end plate **116**, which is clamped directly to the front cam bearing **124**.
- Better alignment with the camshaft **130** because the inner sleeve **151** locates on the inner diameter of the front cam bearing **124**.

FIG. **5** shows a modification of the assembly of FIGS. **3** and **4**. In this embodiment, the front trigger ring **270** is sealed at **274** relative to the front end plate of the phaser **214** to define a cavity **276**. Pressurised oil is allowed to pass into the cavity **276**. Because the trigger ring **270** is clamped to the cam bearing **224**, pressure in the cavity **276** forces the front end plate **214** and the stator **212** rearwards onto the rear plate **216**. This has the net effect of reducing the clearances within the phaser, reducing internal leakage and hence improving overall performance.

We claim:

1. A camshaft comprising an inner shaft and an outer tube that are rotatable relative to one another, a first set of cams secured for rotation with the outer tube, and a second set of cams rotatably mounted on the outer tube and connected for rotation with the inner shaft by way of pins that pass with clearance through circumferentially elongated slots in the outer tube, and a phaser mounted at one end of the camshaft, wherein the phaser has a stator connectible for rotation with an engine crankshaft and two output members each mounted for rotation in unison with a respective one of the inner shaft and the outer tube of the camshaft, the output members having timing features rotatable in unison therewith for enabling respective sensors to determine the angular positions of the inner shaft and the outer tube of the camshaft, and wherein both the timing features rotatable in unison with the respective output members of the phaser are located on the same side of the stator remote from the camshaft, the timing features on the same side of the stator being rotatable relative to each other.

2. The camshaft of claim **1**, wherein the stator is supported on a support bearing which is connected for rotation with the outer tube of the camshaft and one of the timing features, the support bearing having a co-axial inner sleeve connected for rotation with the inner shaft of the camshaft and the other of the timing features.

3. The camshaft of claim **2**, wherein the phaser is vane-type twin phaser, the output members being formed by two end plates of the phaser.

4. The camshaft of claim **3**, wherein the rear end plate of the phaser is connected directly to the outer tube of the camshaft.

5. The camshaft of claim **4**, wherein the timing feature indicating the angular position of the rear end plate of the phaser is formed as a separate trigger ring located at the front end of the phaser remote from the camshaft; the trigger ring, the support bearing and the rear end plate being clamped to the front of the camshaft.

6. The camshaft of claim **5**, wherein the rear face of the trigger ring serves to control the internal clearance between the end plates of the phaser.

7. The camshaft of claim **6**, wherein a space between the trigger ring and the front end plate of the phaser is sealed to define a hydraulic cavity which, when pressurised, applies a force to reduce clearances within the phaser.

* * * * *